Major air pollution incidents and a model for estimating the risk from acute particulate exposure on public health

Simon Griffiths

Senior Lecturer Environmental Health and Environmental Studies, Northumbria University

simon.griffiths@northumbria.ac.uk

Presentation overview

Northumbria University NEWCASTLE

- Introducing major air pollution incidents and the UK's Air Quality Cell (AQC)
- What we learn from Air Quality Cell data: emissions and nature
  - Focussing only on particulates
- Exposure to emissions: public health significance
  - Proposed probability model for assessing health impacts

Major major air pollution incidents

Buncefield Fuel Depot (2005)

- The term ‘major incident’ implies the scale of the type of incident concerned and is a label reserved for situations that pose a serious threat to public health, or cause a significant number or type of causalities, such that special arrangements are needed to manage them (NHS England, 2015).
- https://www.youtube.com/watch?v=N-M-z9JYX0Y

Post event review:
Statutory Major Incident Investigation Board

A review board established by HSE to review the response and management of COMAH ‘major incidents’ see http://www.hse.gov.uk/comah/buncefield/response.htm

- **‘Recommendation 21** The CCS should conclude their review of arrangements for obtaining and using air quality data in an emergency. This revision of arrangements should be delivered no later than 2008. The review should include:
  - agreement on clear **notification procedures**;
  - agreement on **roles and responsibilities for collecting air quality data**;
  - arrangements to **disseminate** the above to **all responders** and include them in emergency plans;
  - agreement on **performance standards for quality and delivery**;
  - consideration for the provision of **local meteorological stations** in the vicinity of COMAH sites, which can provide local wind direction and speed.

Defra should ensure that financial or resource restraints do not hinder the delivery of a robust air monitoring capability.’

[Online] Available at http://www.hse.gov.uk/comah/buncefield/miib-final-volume2b.pdf (accessed 18th March 2019) page 22.

Learning from prior incidents

Northumbria University NEWCASTLE

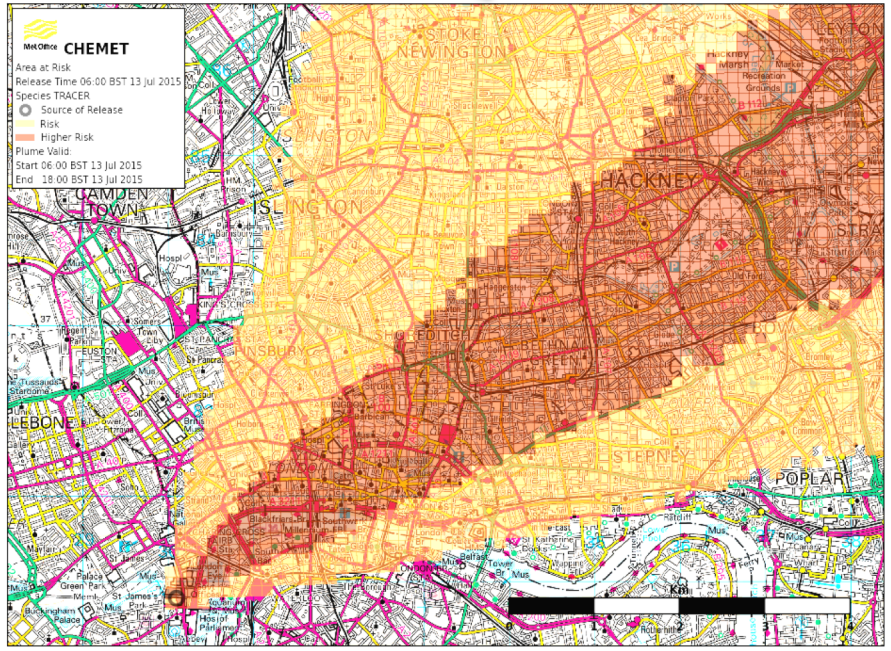
- **United Nations' Sendai Framework (2015 - 2030)**
- Focus on disaster risk reduction with an emphasis placed on health:

1. Use **post-disaster reviews** as opportunities to enhance learning and public policy and share these
2. Promote scientific research of disaster **risk patterns**, **causes** and **effects**
3. **Disseminate risk information** with the best use of geospatial information technology
4. Identify **research and technology gaps** and set recommendations for research priority areas for disaster risk reduction
5. Promote and support the availability and application of **science and technology to decision making**

After Aitsi-Selmi and Murray (2015)

AQC: A tiered response

- **Level 3 (the AQC with monitoring)**
  - Monitoring deemed necessary to
    - Inform ongoing environmental and public health risk assessments
    - Validate decision making
    - Underpin public health advice
  - Choice of monitoring location agreed between environmental regulators + public health advisors
    - Modelled plume behaviour e.g. CHEMETs
    - Availability of appropriate services e.g. electricity for monitoring equipment
    - Occupational health and safety of the responding crew

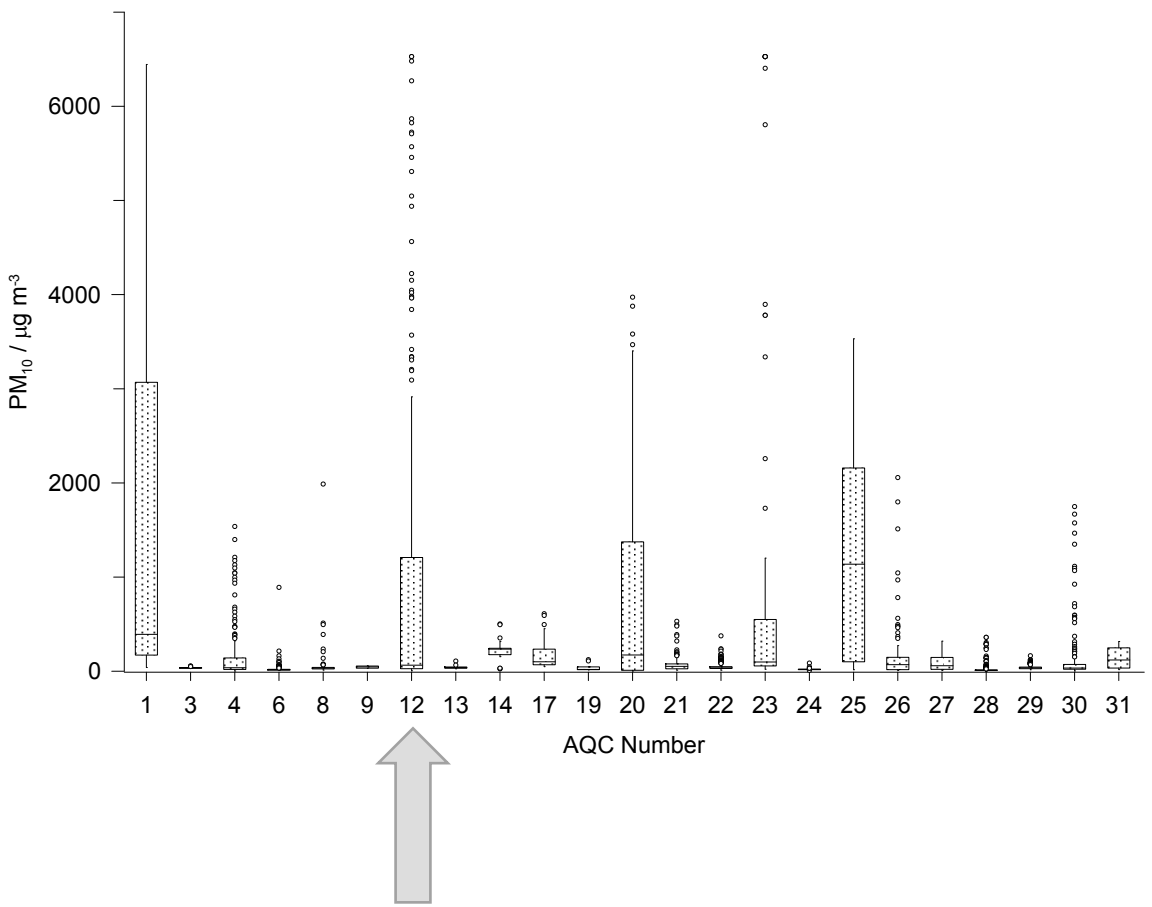


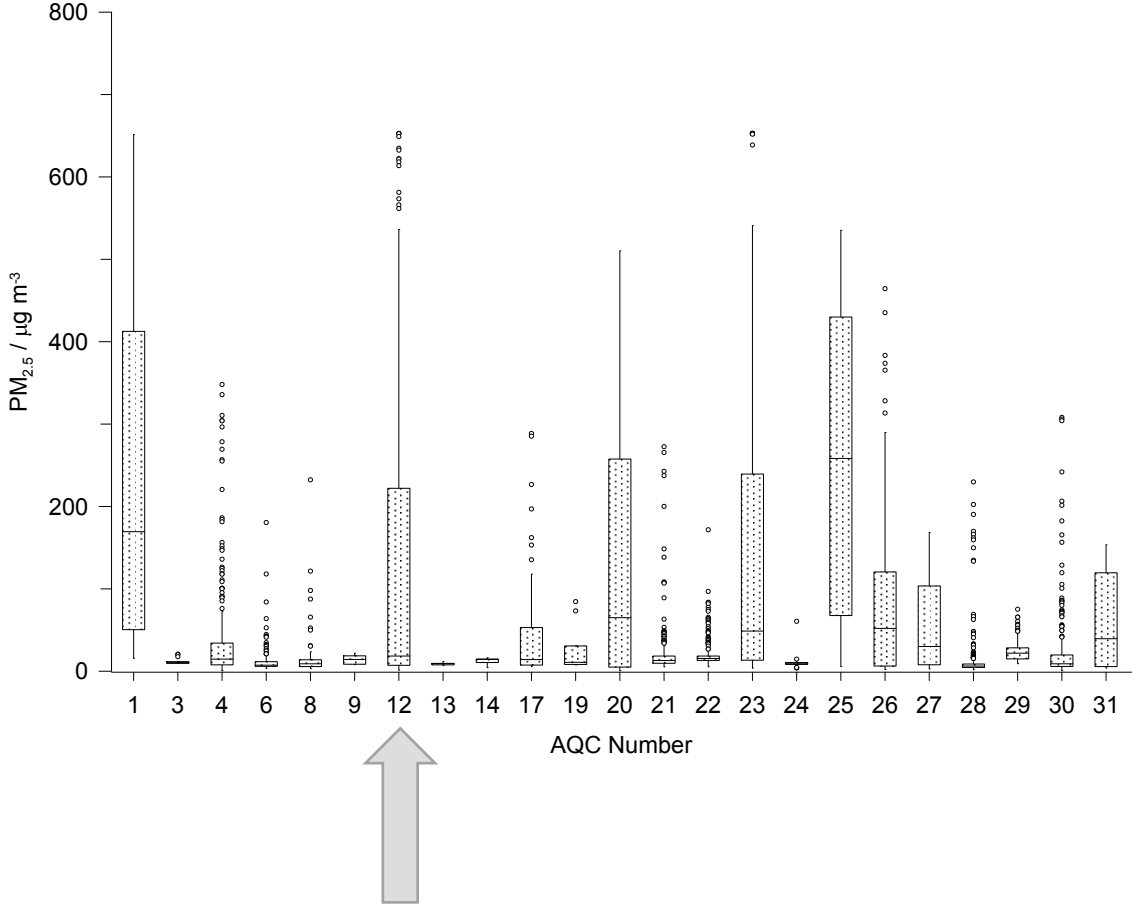
Monitoring

- Monitoring
  - Direct
    - Light scattering (particulate)
    - FTIR (organic)
    - Electrochemical (Cl_2 CO)
  - Collect
    - Filters (particulate / metals)
    - Impinger (cyanide / ammonia)
    - PUF filters (PAH, PCB, organochlorine)
    - Filters (asbestos)

Range of PM_{10} + $PM_{2.5}$ monitored by Environment Agency across 23 incidents

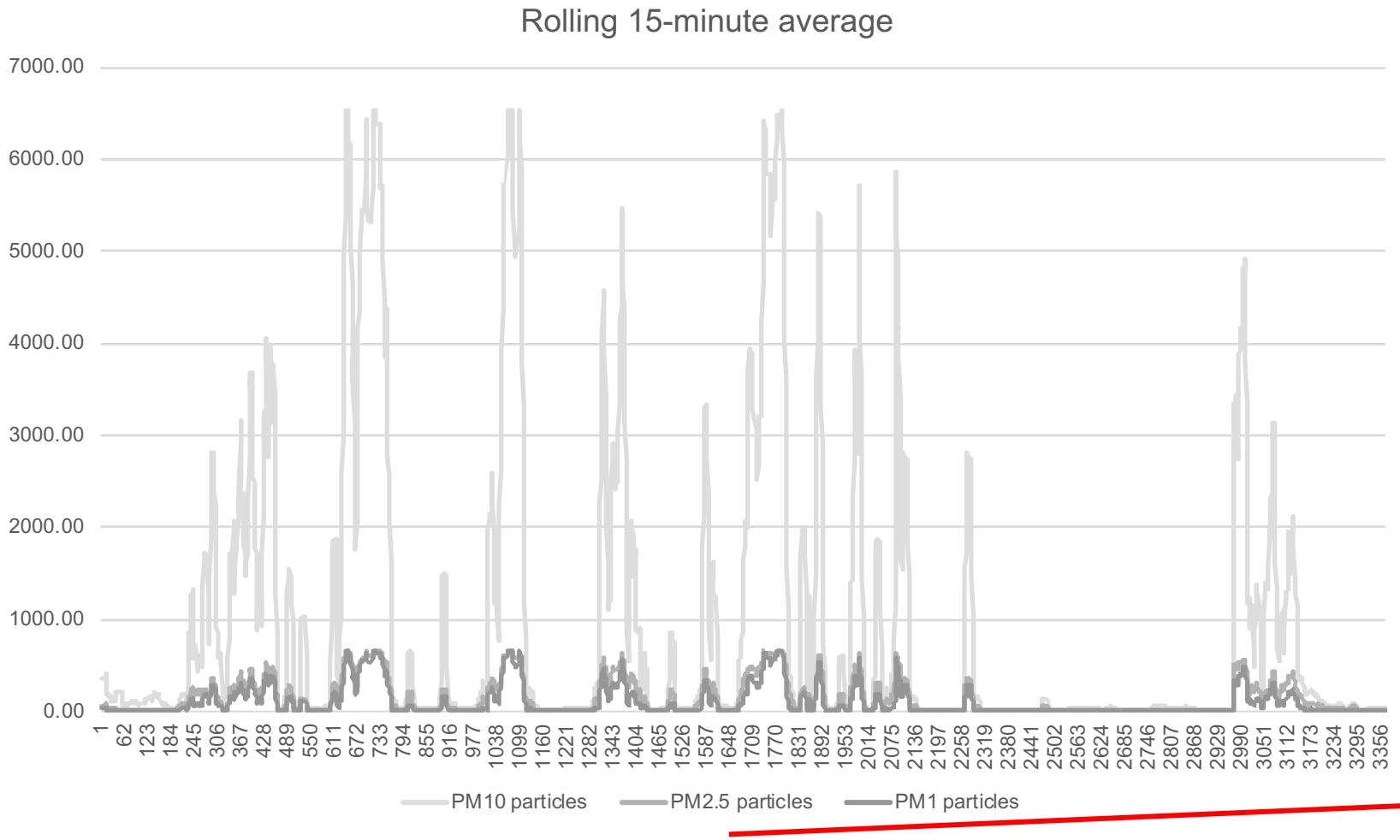
Northumbria University NEWCASTLE





Mexborough Tyre Waste fire (AQC12)

Northumbria University NEWCASTLE



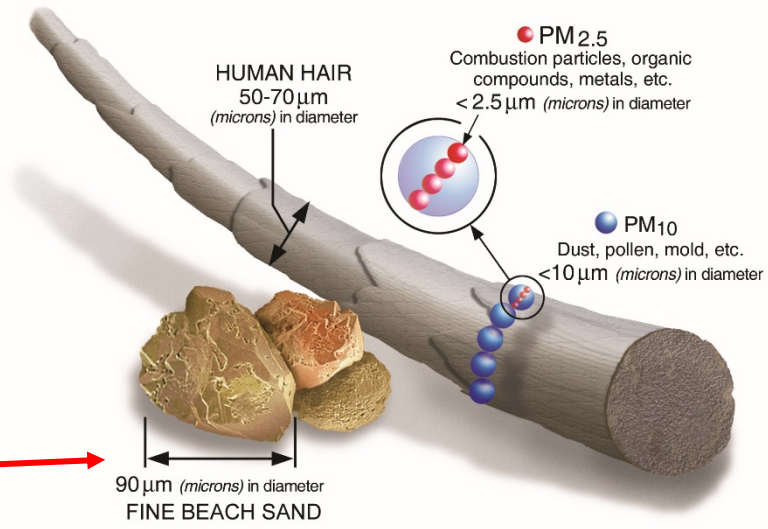
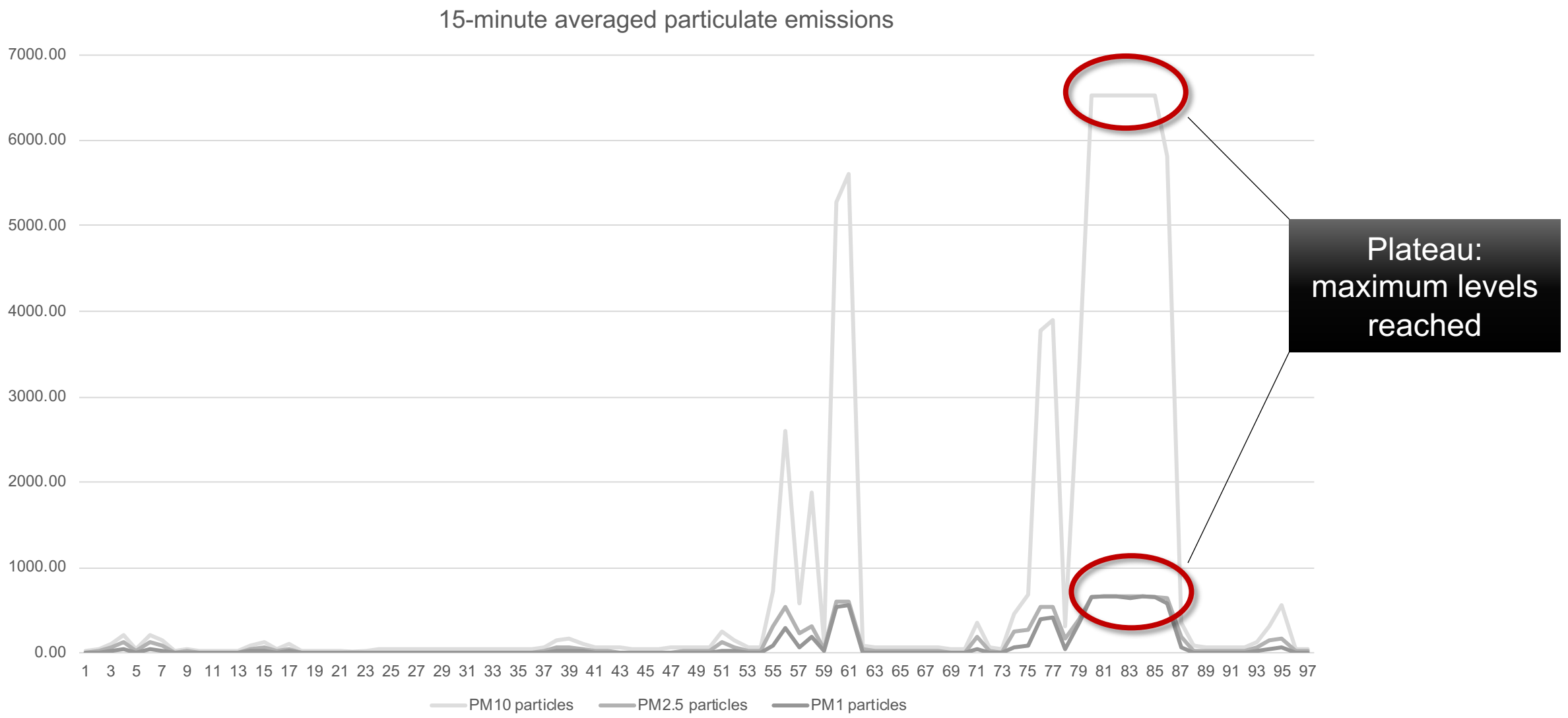


Image: [Online] https://www.epa.gov/pm-pollution/particulate-matter-pm-basics (accessed 18th July 2019)

Monitoring artefact? Levels higher?

Northumbria University NEWCASTLE



Health standards: particulates (PM_{10} and $PM_{2.5}$)

- EU standards (Directive 2008/50/EC on ambient air quality and cleaner air for Europe)

PM_{10}	50 µg/m3	24 hours
	40 µg/m3	1 year
Fine particles ($PM_{2.5}$)	25 µg/m3	1 year

- WHO guidelines (World Health Organisation, 2006)

PM_{10}	10 µg/m^3	1 year
	25 µg/m^3	24 h (99th percentile)
$PM_{2.5}$	20 µg/m^3	1 year
	50µg/m^3	24 h (99th percentile)

Northumbria University NEWCASTLE

Health standards

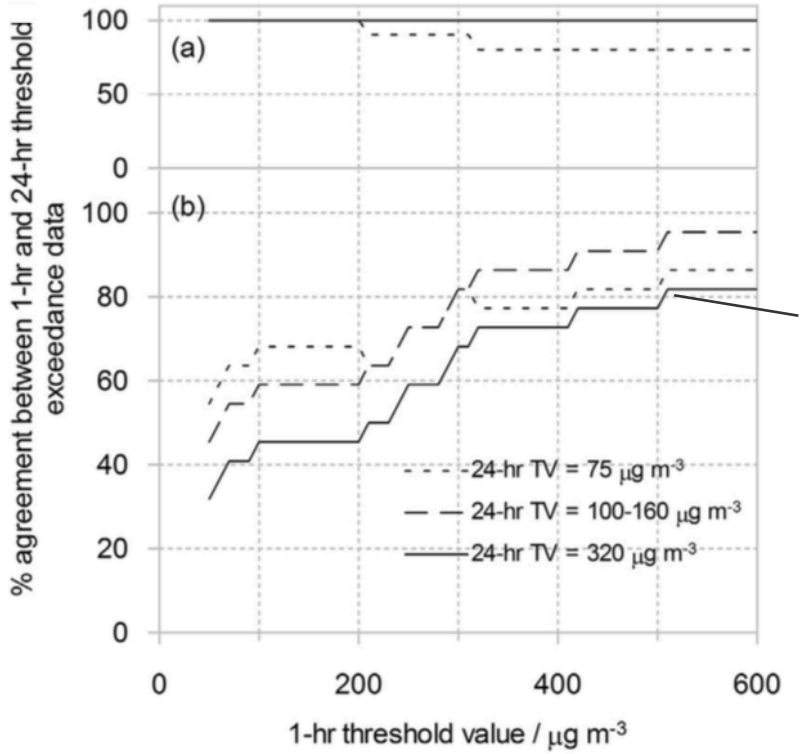
Northumbria University NEWCASTLE

PM_{10} (µg m^{-3})	$PM_{2.5}$ (µg m^{-3})	Description	Health effects/Advice / recommended actions
75	37.5	WHO Interim target-3	Equates to an approximately 1.25% increase in short-term mortality over that for the short-term WHO Annual Quality Guideline (50 for PM_{10} µg m^{-3} and 25 µg m^{-3} or $PM_{2.5}$)
100	50	WHO Interim target-2	Equates to an approximately 2.5% increase in short-term mortality over that for the short-term WHO Annual Quality Guideline (50 for PM_{10} µg m^{-3} and 25 µg m^{-3} or $PM_{2.5}$)
160	-	UK Trigger to Close Public Buildings (Brunt and Russell 2012)	Schools, nurseries, day-care centers and other similar facilities should be closed (to be interpreted and implemented in conjunction with other observations such as the vertical and lateral spread of the plume, whether it is grounding, etc).
320	-	UK Trigger to Evacuate (Brunt and Russell 2012)	When this 24-hour average has been reached, and concentrations are predicted to continue at higher than this level for a further 24 hours, then evacuation should be considered.

Adapted from (Griffiths, *et al*, 2018)

Probability model: flexible 24-hour standard using 1-hour's levels

Northumbria University NEWCASTLE



PM_{10}: 320ugm^{-3} 24h (evacuation) then 510ugm^{-3} for 1 h gives 80% confidence

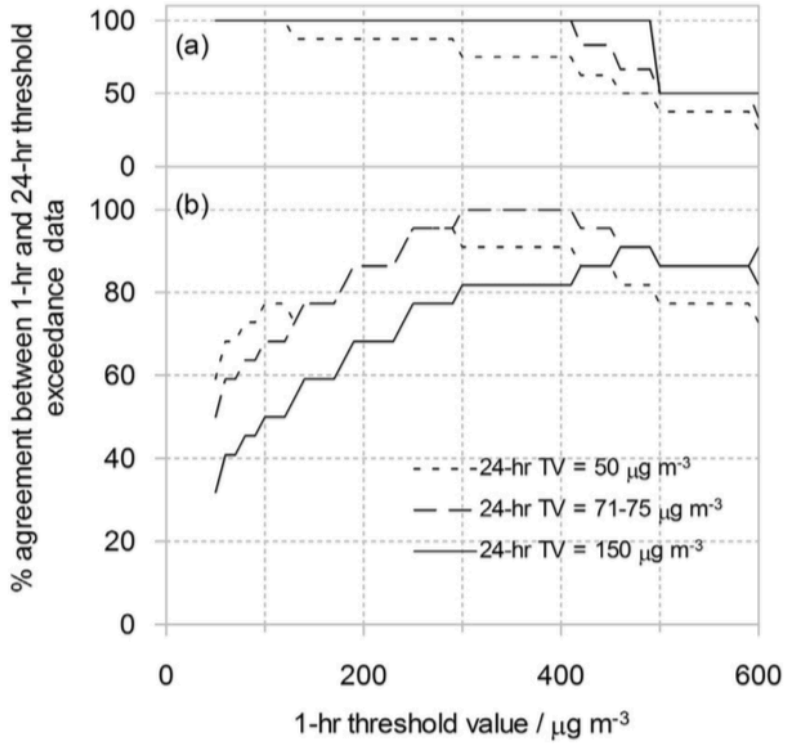


Fig. 6. Percentage agreement between within-incident exceedance of threshold values (TV) for rolling mean 1-h PM_{10} concentrations and selected TVs of public health protection significance for rolling mean 24-h concentrations across 23 major incident fires. Panel (a) shows the percentage of incidents where exceedance of the 24-h TV was correctly predicted by 1-h TV. Panel (b) shows the percentage of incidents where the exceedance/non-exceedance of the 24-h TV was correctly predicted by 1-h TV.

Fig. 7. Percentage agreement between within-incident exceedance of threshold values (TV) for rolling mean 1-h $PM_{2.5}$ concentrations and selected TVs of public health protection significance for rolling 24-h concentrations across 23 major incident fires. Panel (a) shows the percentage of incidents where exceedance of the 24-h TV was correctly predicted by 1-h TV. Panel (b) shows the percentage of incidents where the exceedance/non-exceedance of the 24-h TV was correctly predicted by 1-h TV.

Extracted from Griffiths, et al (2018). A study of particulate emissions during 23 major industrial fires: Implications for human health, *Environment International*, 112, 310-313.

Conclusions

- **Learning** from this study:
  - Waste management sites (including illegal ones) are the unintended consequence of a sustainable resource management so there is a need to look at fire prevention at the sites
  - Significant variation in levels of particulates (more akin perhaps to occupational standards)
  - New probability model to apply to standards chosen to protect public health – flexibility

- **Future** work:
  - Analysis of organic and inorganic compounds for trends and correlations between them
  - Modelling of emissions recorded in the lower risk areas to provide higher risk plume levels
  - Retrospective appraisal of human health outcomes against AQC data
  - Defining population affected by these emissions (and perhaps look at syndromic surveillance to look at potential health outcomes)

Northumbria University NEWCASTLE

Thank you.

Griffiths, Simon, Chappell, Philip, Entwistle, Jane, Kelly, Frank and Deary, Michael (2018) A study of particulate emissions during 23 major industrial fires: implications for human health. *Environment International*, 112. pp. 310-323. ISSN 0160-4120

Simon Griffiths

simon.griffiths@northumbria.ac.uk

References

BRUNT, H. & RUSSELL, D. 2012. Public health risk assessment and air quality cell for a tyre fire, Fforestfach, Swansea. *Chemical Hazards and Poisons Report*, 7-12.

BUNCEFIELD MAJOR INCIDENT INVESTIGATION BOARD 2007. Recommendations on the emergency preparedness for, response to and recovery from incidents. Buncefield Major Incident Investigation Board.

BUNCEFIELD MAJOR INCIDENT INVESTIGATION BOARD 2008a. The Buncefield Incident 11 December 2005 The final report of the Major Incident Investigation Board Volume 1. Buncefield Major Incident Investigation Board.

BUNCEFIELD MAJOR INCIDENT INVESTIGATION BOARD 2008b. The Buncefield Incident 11 December 2005 The final report of the Major Incident Investigation Board Volume 2. Buncefield Major Incident Investigation Board.

GRIFFITHS, S. D., CHAPPELL, P., ENTWISTLE, J. A., KELLY, F. J. & DEARY, M. E. 2018. A study of particulate emissions during 23 major industrial fires: Implications for human health. *Environment International,* 112, 310-323.

NHS ENGLAND 2015. Emergency Preparedness, Resilience and Response Framework. *In:* NHS ENGLAND (ed.) 2.0 ed. Leeds: NHS England,.

WORLD HEALTH ORGANISATION 2006. *Air Quality Guidelines: Global Update 2005. Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide*, World Health Organization.